



## Sodium Bicarbonate as A Replacement for Hyaluronidase in Ocular Anesthesia During Cataract Surgery

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### ABSTRACT

*For a cataract extraction, the ideal anesthetic needs to have a rapid onset and long action. The local anesthetic solutions supplied as acidic salts avoid precipitation during storage. Alkalinisation of the LA agent with sodium bicarbonate increases drug penetration through the soft tissues and nerve sheath, thus decrease the duration of onset of action.*

*Thereby the following study was conducted by replacing hyaluronidase with sodium bicarbonate where safety profile, onset of anesthesia and cost was evaluated. The study concluded that Sodium bicarbonate with lidocaine is recommended as an adjunct to hyaluronidase as a LA agent taking into account the anesthetic effect, with virtual freedom from complications and cost effectiveness.*

**KEYWORDS :** sodium bicarbonate, hyaluronidase, akinesia, peribulbar anesthesia

### INTRODUCTION

When planning for a surgery, one cannot think of performing it without appropriate anesthesia. However a cataract surgery, for example, can be performed without local anesthesia (LA).

The LA selected for ophthalmic surgery is mostly used in combination with adjuvants. For a cataract extraction, the ideal anesthetic would need to have a rapid onset and long action. Traditionally, the anesthetic solution used was a mixture of 30 ml of 2% lidocaine with 1:200000 dilution component of epinephrine and 450 Units (150U/ml) of hyaluronidase.<sup>1</sup>

Knapp (1884)<sup>2</sup> has described the technique of retrobulbar anesthesia. While Atkinson (1994)<sup>3</sup> reported the advantages of hyaluronidase with anesthetic solution when a large volume, early akinesia and anesthesia were required.

Hyaluronidase (an enzyme) catalyzes the depolymerization of hyaluronic acid to a tetrasaccharide, which improves the efficacy of LA by breaking down interstitial cell barriers, thus facilitating diffusion of the anesthetic solution. Its availability and cost however remain a problem<sup>4,5</sup>.

Therefore, a readily available, safe, low cost, efficient substitute was needed.

The LA solutions are supplied as acidic salts to avoid precipitation during storage. Alkalinisation of the LA agent with sodium bicarbonate increases drug penetration through the soft tissues and nerve sheath, thus decreasing the duration of onset of action<sup>6</sup>.

Galindo et al (1983)<sup>6,7</sup> stated; altering the pH of LA with sodium bicarbonate, in 1:10 mixture with lidocaine or bupivacaine, enhances the onset time and spread of neural blockade significantly. As sodium bicarbonate increases the non-ionic forms of the drug, penetration through the soft tissue is faster, offering reduced duration of onset of action. Significant reduction in pain was reported, when buffered injections were used as compared to unbuffered injection for eyelid anesthesia.<sup>8</sup>

Considering the advantages of sodium bicarbonate, a study was performed to evaluate its efficacy over hyaluronidase with the following objectives.

### OBJECTIVES

- 1) To evaluate the safety profile of sodium bicarbonate.
- 2) To evaluate the efficacy regarding onset and total duration of an-

esthesia.

- 3) To evaluate the cost effectiveness.

**STUDY DESIGN:** Randomized Cross-sectional Study

### MATERIALS AND METHODS

This randomized cross-sectional study was performed in the Department of Ophthalmology (AVBRH). Patients undergoing cataract surgery were selected randomly for the study. They were further divided into two groups with 100 patients each.

**DURATION OF STUDY:** 2 years

**SAMPLE SIZE:** 200 patients

### EXCLUSION CRITERIA

- 1) Patients on pre-operative sedatives, analgesics or anxiolytics.
- 2) Patients with profound cognitive impairments who couldn't grade for pain or could give the informed consent.
- 3) Patients with sensitivity to lidocaine or hyaluronidase.
- 4) Patients with hypertension, ischemic heart disease, diabetes, glaucoma, bronchial asthma and previous eye surgery.

**Group A** patients received a mixture of LA containing 30 ml of 2% lidocaine with 1:200,000 epinephrine and 1 ml of 7.5% sodium bicarbonate (0.299 mmol/ml), with pH 7.2.

**Group B** patients received mixtures of LA containing 30 ml of 2% lidocaine with 1:200,000 epinephrine and 450 units of hyaluronidase (15U/ml), with pH 4.6.

The surgeon administering the peribulbar anesthesia assessed akinesia and anesthesia for all 200 pts. Grading system was used for the time of onset of anaesthesia and akinesia.

Within 1 to 2 min

Within 2 to 5 min

Within 5 to 10 min

If more than 10 minutes, repeat the block.

**Grades for anesthesia and akinesia**

Grade I	Grade II	Grade III
Complete anesthesia and akinesia featuring	Akinesia and anesthesia considered adequate for safe intraocular surgery featuring	Unsuccessful akinesia and anesthesia featuring
Complete absence of eye movement	Eye movement less than 15° in any direction of gaze	Eye movement more than 15° in any gaze
Complete anesthesia of conjunctiva and cornea	Complete anesthesia of conjunctiva and cornea	Complete anesthesia of conjunctiva and cornea
Painless insertion of the superior rectus bridle suture	Painless insertion of the superior rectus bridle suture	Painless insertion of the superior rectus bridle suture

If patients were seen with grade 3 anesthesia, they were supplemented with injection of the same mixture at 10 min intervals. The time taken for the surgery was recorded from the time injection was given until the time patient leaves the room.

All the patients were given topical antibiotic - steroid eye drops six times a day; and 1% cyclopentolate once a day, post-operatively. On the first and second postoperative days, patients were examined under a slit lamp bio-microscope, for adverse effects of anesthetic agents, like chemosis, conjunctival congestion and lid oedema. Fundus examination was done with direct ophthalmoscope and with +90 D lens. Visual acuity was recorded on day two before patient discharge. Follow-up was done at 4, 8, and 12 weeks for all patients.

All the findings were subjected to statistical analysis and the following observations were drawn.

**OBSERVATIONS**

**Table I: Time taken for onset of anesthesia**

Time taken for onset of anesthesia	Anesthetic Agent				χ <sup>2</sup> -value	p-value
	Lidocaine+ Bupivacaine+ Sodium Bicarbonate Group A		Lidocaine+ Bupivacaine+ Hyaluronidase Group B			
	N	%	N	%		
Within 1-2 min	18	18.00	06	06.00	6.81	p<0.05
Within 2-5 min	82	82.00	94	94.00		
Within 5-10 min	-	-	-	-		
Total	100		100			

**The mean for group A was 4.88 minutes ± 3.24, and for group B was 5.27 minutes ± 2.99.**

**Table II: Time required for complete anesthesia**

Time(min)→ Group↓	< 5 min	5-10 min	> 10 min	χ <sup>2</sup> -value
<b>A</b>	44%	35%	21%	30.18
<b>B</b>	12%	70%	18%	p < 0.05

**The mean for group A was 6.79 minutes ± 2.28 and for group B was 8.08 minutes ± 1.72.**

**Table III: Duration of surgery under peribulbar anesthesia**

Local Anesthetic	Time (mins)				χ <sup>2</sup> -value	p-value
	30-40	41-50	51-60	>60		
Group A	44	42	06	08	9.02	p < 0.05
Group B	58	26	12	04		
Total	102	68	18	12		

**Table IV: Time of onset of post-operative pain**

Group	Time (mins)					χ <sup>2</sup> -value
	< 30 min	30-60 min	61-90 min	91-120 min	>120 min	
A	04	10	12	30	44	44.62 p < 0.05
B	14	24	30	24	08	

**The mean for group A was 102.85 minutes ± 32.14 and for group B was 76.45 minutes ± 30.43**

**DISCUSSION**

This randomized cross-sectional study was conducted on 200 patients admitted for cataract extraction, to compare the effects of hyaluronidase and sodium bicarbonate in peribulbar anesthetic mixture.

The incidence of senile cataract is higher after 50 years of age<sup>9</sup>. Out of 200; 98 patients were male and 102 were female. 20 were between 30-40 years of age, 42 were between 41- 50, 66 were between 51 -60 while 72 were above 60 years of age. This was found in congruence with the studies of Srinivasan et al (2000)<sup>6</sup> and Parsons' Diseases of the Eye textbook<sup>9</sup>

The time of onset of anesthesia in group A, was within 1-2 minutes in 18% while it was 5 minutes in 82 %. In group B, the onset was within 1-2 minutes in 6% and within 5 minutes in 94 %. **(Table I).**

Srinivasan et al (2000)<sup>6</sup> stated; that the addition of sodium bicarbonate reduces onset time and improves quality of the block. Also Zahl K. et al (1991)<sup>10</sup> in his study concluded that onset of akinesia is more rapid (i.e.7±2 minutes) after pH adjustment of solutions with bicarbonate, but in their study they added sodium bicarbonate to mixtures of lidocaine, bupivacaine and hyaluronidase. It was observed that with bicarbonate, hyaluronidase had better efficacy, resulting in earlier onset of action.<sup>4,7,11-15</sup>

Unlike the study conducted by Sharma T. et al (2002)<sup>16</sup>, 79% patients of group A achieved complete anesthesia and akinesia within 10 minutes whereas 21% still required supplementary block. The re-block rate was thus 21%. While in group A, 82% patients achieved complete anesthesia and akinesia within 10 minutes. In 18% cases supplementary block was required. Thus the re-block rate was only 18%. The successful block rate was higher in group A than in group B **(Table II)**. Lewis P. et al (1992)<sup>17</sup> and Mantovani C. et al (2001)<sup>18</sup> also observed no significant difference in time to achieve complete anesthesia.

The mean time taken for complete anesthesia and akinesia for group A was 6.79 ±2.28, and group B was 7.09± 1.26 which was similar to the study by Ackermann W.E. et al (1990)<sup>19</sup>.

When associated complications were assessed, in group A, 18% of patients had sub-conjunctival chemosis as compared to group B which was 14%. In this study there were no cases of peribulbar hemorrhage, perforation of globe, injury to optic nerve, central retinal arterial or vein occlusion and vitreous bulge observed. This could be attributed to the sound technique and meticulous care taken in administering the peribulbar block. The observations were similar to the results of Srinivasan M. et al (2000)<sup>6</sup>, Eccarius S.G. et al (1940)<sup>20</sup>.

For systemic safety profile analysis, no change in pre-block, post-block blood pressure or heart rate were found. While similar results were given by Sarvela P. J. et al (1993)<sup>4</sup>, Lewis P. et al (1992)<sup>17</sup>, Minasian M.C. et al (2000)<sup>21</sup>.

The duration of surgery under peribulbar anesthesia in both the groups was not statistically significant **(Table III)**.

When the duration of anesthesia was evaluated, 44% of patients from group A had onset of pain 2 hours after surgery and 42% had pain between 1-2 hours, while in group B only 8% had onset of pain after 2 hours, 54% within 1 to 2 hours while 38% had onset of pain within an hour of surgery. (Table IV) which was statistically significant.

The duration of anesthesia was significantly longer with sodium bicarbonate than hyaluronidase. Fuchsjäger G. et al (2002)<sup>22</sup>, Drager J. et al (1984)<sup>23</sup>, Zehetmayer M. et al (1996)<sup>24</sup>, Dr Wadhwa P. (2003)<sup>25</sup> also found similar results.

Considering the cost effectiveness; for an effective anaesthesia 1500 IU of hyaluronidase (Rs. 110) was mixed with 30 ml of 2% lidocaine (16.6 U/ml). By utilizing 6 ml of this mixture per patient, 5 patients could be anesthetized for Rs. 22 per patient. With 7.5% sodium bicarbonate (Rs. 12 per 10 ml ampoule), mixed with 300 ml of 2% lidocaine (1:30), 50 patients could be anaesthetized for 24 paise per patients.

As more than three million cataract surgeries are performed in India (Murthy et al 2005)<sup>10</sup> around Rs. 36 million is spent for hyaluronidase alone. Sodium bicarbonate can thus be considered a cheaper and effective substitute in conjunction with a local anesthetic in cataract surgery. If sodium bicarbonate could substitute hyaluronidase, it amounts to substantial savings of 35.6 million INR.

#### Thus the present study concludes that:

The use of sodium bicarbonate with LA for cataract surgery is safe and effective with respect to early onset and complete ocular anesthesia, more economical and easily available as compared to hyaluronidase.

With pH adjusted, anesthetic solution related post-operative pain was much later than non pH adjusted solution.

Sodium bicarbonate mixture with lidocaine is recommended as an LA agent taking into account the anesthetic effect, virtual freedom from complications and cost effectiveness.

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